ORGANIZATION AND CONDUCT OF FOREST INSECT AERIAL SURVEYS

IN OREGON AND WASHINGTON

U. S. DEPARTMENT OF AGRICULTURE · FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
R. W. COWLIN, DIRECTOR
PORTLAND, OREGON MARCH 1955

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INTRODUCTION

Aerial surveys are an economical means of detecting and evaluating outbreaks of forest insect pests. Comprehensive annual surveys insure the early detection of epidemic infestations, simplify and reduce costs of follow-up ground surveys, and provide information for the orderly planning of control measures or salvage operations.

The use of airplanes for forest insect surveys in the valuable timbered areas of Oregon and Washington is not a recent development. In 1931, Mr. F. P. Keen, then in charge of the Portland Forest Insect Laboratory, and Mr. C. S. Cowan, Chief Fire Warden of the Washington Forest Fire Association, conducted the first recorded aerial survey of a forest insect outbreak in the two states. They delineated an epidemic of the hemlock looper in Pacific County, Washington, before the start of the first aerial dusting project to control a forest defoliator in the western states. Between 1931 and 1947 airplanes were infrequently used as a survey tool. In 1947 an annual aerial survey program for the forests of Oregon and Washington was instituted by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture and its cooperators. To date these annual surveys have led to the aerial spraying of 3,234,000 acres of spruce budworm and Douglas-fir tussock moth infestations.

This report describes the organization and conduct of annual forest insect aerial reconnaissance surveys of the 49,000,000 acres of forested lands of Oregon and Washington as now practiced by the Division of Forest Insect Research of the Pacific Northwest Forest and Range Experiment Station and its cooperators. Not included in this report are the special intensive surveys, such as the 1952 survey of blowdown areas and beetle damage in the Douglas-fir region.1/

1/ Final Report on the 1952 Blowdown and Bark Beetle Survey in the Douglas-Fir Region of Oregon and Washington. A cooperative project under the supervision of Pacific Northwest Forest and Range Experiment Station USFS and Bureau of Entomology and Plant Quarantine, Portland Forest Insect Laboratory. Portland, Oregon. July, 1953.

Acknowledgment is made of the invaluable assistance and cooperation given by the Weyerhaeuser Timber Company, Oregon State Board of Forestry, State of Washington Division of Forestry, and others in the conduct of the regional aerial survey program. Without their help, this program would have been difficult, if not impossible to accomplish.

PART I

AERIAL SURVEY EQUIPMENT AND PERSONNEL REQUIREMENTS

As a result of the experience gained during the conduct of the regional aerial surveys in Oregon and Washington since 1947, conclusions have been reached regarding several important requirements, especially those having to do with the aircraft used, safety measures, maps, and personnel.

Aircraft Requirements

Aerial surveys to detect and evaluate damage caused by forest insects require an airplane that has the following features: (1) Excellent forward and lateral visibility, (2) good performance at survey altitudes, (3) ample cabin space for handling survey equipment, and (4) adequate cruising range.

Visibility

Maximum forward and lateral visibility is most important to the success of an aerial survey. High-wing aircraft are better suited to these surveys than low-wing monoplanes or biplanes since high wings offer less restriction in lateral visibility. The plane's windows should be sufficiently low so that an observer may look almost vertically beneath the plane. Airplanes with flat engines provide much greater forward visibility than those with radial type engines.

Performance

A survey airplane must have good performance from sea level to 11,000 feet and have a service ceiling of at least 15,000 feet, in order to fly safely at the altitudes required on insect surveys over the rugged mountainous terrain of Oregon and Washington. The plane should also have excellent "slow flight" characteristics since it is often necessary to reduce air speeds to 60 miles per hour for extended periods of time to observe centers of infestation carefully or to count groups of insect-killed trees. The plane must be capable of landing and taking off from airports at high elevations and from airports with short unsurfaced runways.

Cabin Space

The survey plane should have sufficient cabin space to permit observers to manipulate maps and map boards without interfering with the pilot's safe operation of the aircraft. A four- or five-place plane is desirable because of its greater stability in rough air and greater cabin space. A two-place tandem or side-by-side type airplane may be used by a two-man crew, consisting of pilot and observer. A tandem plane enables the observer to view the forest from either side of the plane. But two-place planes have the disadvantages of limited cabin space for handling maps and map boards and of extreme buoyancy in rough air.

Cruising Range

The plane's cruising range should include the actual survey time over the area (which depends upon the size of the area and the intensity of coverage), ferry time to and from the airfield or to fly to an alternate airport if adverse weather prevents landing at the first intended airport, and an additional 30-minute margin of safety. For local surveys, a cruising range of 2 hours may be sufficient; however, on extensive regionwide surveys, the aircraft should be able to maintain cruising speeds for approximately 4-1/2 hours without refueling.

Based on the requirements of visibility, performance, cabin space for handling maps, slow flight characteristics, and cruising range, a 4-place all metal high-wing airplane is preferred by the writers for forest insect aerial surveys. All aircraft operated on regionwide forest insect surveys are listed in Summary A (Appendix); however, the planes considered most suitable for surveys are those flown the past three years.

Safety Precautions

Personnel engaged in forest insect surveys in the Northwest are exposed to hazardous flying because surveys are made close to the ground over high, mountainous, and timbered terrain. Every possible safety precaution in compliance with the U. S. Forest Service Safety Code and the Air Operations Handbook is taken to prevent accidents.

The survey plane is carefully inspected before every flight; 25-hour periodic checks are made in addition to the regular checks by a licensed mechanic required by the Civil Aeronautics Administration. Log books are kept up to date and properly certificated. The plane is equipped with CAA-approved shoulder harness and seat belts capable of withstanding the shocks of a forced landing. It is equipped with a jettisonable door, fire extinguisher, first aid kit, hatchet, and emergency rations. All aircraft instruments and gauges are kept in perfect working order. The survey aircraft is painted in a high-visibility red and yellow for air safety and contrast to ground vegetation.

The useful load carried by the airplane is reduced at least 25 percent below capacity on forest insect surveys. This reduction improves landings and take-offs from small high-elevation airports. The reduction also reduces the hazards of low flying above the timber during the hottest and most turbulent part of the day, especially when operating at high elevations.

The planes used have slow landing speeds and can make safe landings in extremely small areas. In an emergency, a forced landing would generally be preferred to a jump when a field, road, or dense stand of young trees is available. Over tall timber a jump usually would be preferred because CAA records in the Northwest show that, regardless of the type or size of aircraft, there is only a 5 percent chance of surviving a plane crash in tall timber.

The crew is equipped with the latest type, quick-opening back pack parachutes. These are worn at all times during flight. Because the plane frequently flies at minimum altitude, where seconds count in an emergency, the entire crew is thoroughly indoctrinated in "bail out" procedures. With practice on the ground the plane can be abandoned in 20 seconds. Under actual conditions the full crew would be free floating in 25 seconds; the resulting loss in vertical distance during bail out would be approximately 250 feet. Parachute jumps are not recommended by the U. S. Forest Service below 800 feet.

Reliable radio communications are maintained for safe aerial operations. Position reports, weather information, and special reports are received and transmitted during all survey flights. Position reports are transmitted at least every 30 minutes to a CAA range station or other reliable radio facility.

Over relatively level terrain at survey altitude, VHF (high frequency) radio transmission is used because it is generally clear and free from static. VHF transmission, however, is line-of-sight and signals are frequently blocked by terrain. Therefore, low frequency radio transmission is used in mountainous terrain due to the arc of the radio's transmitted signal. The survey plane's low frequency radio is equipped with a trailing antennae to obtain maximum transmitting and receiving range. A communication network is mandatory for aerial surveys in the Northwest to maintain continual contact with the survey aircraft. It should include the continued use of CAA low frequency and VHF units and a system of mobile or fixed receiving and transmitting stations.

Survey Maps

Maps of various scales and types are used in aerial surveys. The type and scale of reconnaissance map selected depends upon the intensity of the survey. Planimetric maps at 1/4-inch per mile, such as published by the U. S. Forest Service, have proven satisfactory for recording infestations on the annual regionwide reconnaissance. These maps have sufficient cultural detail to map infestations with considerable accuracy, but the scale is too small to accurately denote the size of small spot infestations.

On the more intensive surveys, maps of 1/2 to 1-inch per mile scale are employed. Where precise mapping is required, large scale contour maps, U.S.G.S. quadrangle sheets, or aerial photographs are used. Flight lines, boundaries of insect infestations, and other information are drawn either directly on the map or on transparent overlays.

Personnel Requirements

The information derived from the aerial surveys must be of the highest quality. Careful selection and training of qualified observers and skilled pilots are essential to the success of an aerial forest insect survey. Personalities of crew members must be compatible to permit work under the exacting conditions in the limited space of a plane.

Observer's Background

The prospective forest insect observer should have certain basic experience and ability to be considered for aerial surveys. He should have:

a. Inherent desire to participate in aerial activities.
b. Good eyesight and good color perception.
c. Physical and mental stamina to observe continuously for periods of 2-1/2 to 3-1/2 hours and to remain aloft for at least 4 hours without great discomfort.
d. Forestry background to enable him to recognize various tree species.
e. Wide knowledge of forest insects and at least two seasons on forest insect ground surveys to enable him to recognize and evaluate various types of insect damage.
f. Ability to read maps and the coordination necessary for accurate aerial navigation and sketchmapping.
g. A medical examination for aerial physical fitness.

Training Observers

It has been found from past experience that approximately 25 hours in the air are required to train an observer to become proficient in aerial survey methods. The first 10 hours are devoted largely to orientation, observing tree species, and identifying various types of tree damage. During the next 15 hours, the observer develops his ability to navigate accurately, to space flight lines properly, to judge distance and size of areas from various heights, and to sketchmap infestations and other tree damage accurately. Several hours of reorientation are required by experienced observers after a break of 5 or 6 months. Long experience is necessary for an observer to become expert.

Pilot's Background

The pilot selected for forest insect aerial surveys must be well-qualified in mountain flying at reconnaissance survey altitudes. He must have excellent map reading ability and skill to fly predrawn flight lines on large scale maps at survey altitudes over rough mountainous terrain. Pilots must have sound judgement, even temperament, cooperative attitude, and other character traits essential to the competent operation of aircraft on this type mission. Since the safety of plane and personnel on the survey is largely the pilot's responsibility, his experience and general qualifications must equal or exceed the following minimums prescribed in the U. S. Forest Service Air Operations Handbook.

a. At least 1000 hours of flying experience as pilot in command including the following:

b. At least 200 hours of flying in the typical terrain and from all type landing facilities similar to those to be found on the survey project.

c. At least 100 hours in the general class of observation plane to be used on the survey project.

d. At least 200 hours of cross-country flying.

e. At least 100 hours during the preceding 12 months of which at least 10 hours shall be under conditions described in (b) above.

f. Hold a currently valid commercial pilot's certificate with appropriate ratings and a current medical certificate complying with CAA regulations and applicable State regulations.

PART II

AERIAL SURVEY PROCEDURES

Scheduling Regionwide Surveys

Aerial surveys must be conducted when forest insect damage is most evident; otherwise, infestations may be misinterpreted as to severity or overlooked entirely. The period when insect damage is most visible varies with the insect species and its geographical distribution. However, defoliator damage and bark beetle killing overlap sufficiently that, by proper scheduling, several types of insect damage can be detected and recorded on the same survey (table 1 and table 2). Where bark beetles produce more than one generation per year, portions of the area may have to be resurveyed to complete the infestation picture. The regional survey usually is carried on in Oregon and Washington between July 1 and October 1, which provides maximum detection of the principal insects with a minimum of duplicate flying.

Defoliator Surveys

Defoliator surveys are designed to evaluate current season's damage. The optimum period for detecting defoliator damage from the air usually begins when larval feeding nears completion and lasts for 3 or 4 weeks. Heavy defoliation can be observed for longer periods. Seasonal or climatic conditions may advance or retard a particular insect's development and consequently influence the scheduling of an aerial survey. The evidence of epidemic defoliation is adversely affected by strong winds and heavy rains which remove the damaged foliage. Cloud shadows and light overcast make defoliation more difficult to see. Haze or smoke reduces visibility and may preclude further aerial reconnaissance.

Table 1. Aerial reconnaissance schedule for defoliator outbreaks in Oregon and Washington

Tree Species	Defoliator	Survey Period
Douglas-fir	Spruce budworm	July 1 - Sept. 1
	Douglas-fir tussock moth	July 1 - Sept. 1
True firs	Spruce budworm	July 1 - Sept. 1
	Douglas-fir tussock moth	July 1 - Sept. 1
	Black-headed budworm	July 1 - Sept. 1
	Balsam woolly aphid	undetermined
	Fir sawflies	July 1 - Aug. 15
Western hemlock	Hemlock looper	Aug. 15 - Oct. 1
	Black-headed budworm	July 1 - Sept. 1
	Hemlock sawfly	July 1 - Aug. 15
Sitka spruce	Spruce aphid	July 1 - Aug. 1
Lodgepole pine	Lodgepole sawfly	July 1 - Sept. 1
	Lodgepole needle miner	July 1 - Aug. 15
	Pine budworm	July 15 - Sept. 15
Ponderosa pine	Pine butterfly	Aug. 1 - Oct. 1
	Pandora moth	July 1 - Oct. 1
	Pine budworm	July 15 - Sept. 15
Western larch	Larch bud moth	July 1 - Aug. 15

1. Douglas-fir--Spruce budworm larvae prefer new foliage. They eat old foliage only after the new foliage is consumed. Much of the partly eaten or injured foliage remains attached to branches by webbing which the larvae spin among the twig tips. These needle fragments soon turn reddish and become most colorful about the time the budworm pupates. Defoliation is most severe in the tops of trees, and is usually more pronounced in young understory trees. When the epidemic is severe, trees of all ages are stripped of foliage and large areas of the forest take on a scorched brownish appearance.

Douglas-fir tussock moth outbreaks are most conspicuous early in the season when feeding by the young larvae causes many of the new needles to turn a bright sorrel. White webbing which the young migrating larvae spin over the tree crown is also outstanding at this time. Tree tops are defoliated first. Feeding is more pronounced on the young understory. In severe epidemics trees of all ages over large areas may be completely stripped of foliage and killed.

2. True firs--Spruce budworm larvae feed on new needles until the supply is exhausted; then they attack the older foliage. Needles injured by feeding soon fade, and the damage becomes most apparent about the time budworm pupation starts. Defoliation is most severe in the tops of the trees and is usually more pronounced on the young understory. Wind or rain soon removes the damaged foliage.

Douglas-fir tussock moth damage is conspicuous early in the season due to the habits of the young larvae. They consume the pulp on the underside of needles leaving the hard upper shell. This remaining portion soon turns a bright sorrel. The young larvae indulge in a short period of frantic migration, especially upward, and spin a silken strand wherever they travel. A heavy population of migrating larvae soon covers the trees with a shimmering canopy of white silk which also is conspicuous for a short time. Defoliation first occurs in the tops of trees. As the upper foliage is destroyed, the caterpillars work downward. Larval feeding is more pronounced on the young understory. Under severe epidemic conditions trees of all ages may be completely stripped of foliage and killed.

The black-headed budworm consumes the new foliage and then attacks the old needles. The larvae do considerable webbing about the twig tips. Many partially eaten or injured needles adhere to the webbing and fade, causing the forest to take on a reddish brown appearance during epidemics. Trees of all ages are attacked, but defoliation is most severe on the understory.

The balsam woolly aphid feeds on the main bole and on the branches, causing the branches to become gouty and gradually lose their foliage over a period of years. Killing is slow. Trees of all ages are attacked. Sparseness of foliage and a black gouty appearance of the branches of heavily attacked trees are the meager clues to a developing infestation. The best time of year for aerial detection has not yet been determined.

Fir sawflies feed almost exclusively on old foliage. Much of the needle is consumed. The injured needles soon fade and their color aids materially in detecting an outbreak. Nevertheless, the sawflies' habit of feeding first on the lower branches makes it difficult to detect an outbreak from the air until the infestation has become serious. Another difficulty is that new foliage soon obscures the evidence of defoliation.

3. Western hemlock--Hemlock looper larvae start feeding on the understory branches and work upward. The larvae are wasteful feeders frequently taking only a bite or two out of a needle. Most injured needles fall without fading. However, a few remain, especially on trees in sheltered locations. These needles fade, giving the stand a yellowish to brown appearance. Light infestations are difficult to detect as the damage first occurs on the lower portion of the crown. As the infestation increases, foliage in the upper crown becomes sparse; then small groups and patches of heavily defoliated trees appear. In severe epidemics the defoliated trees die, turning brown and later grey on extensive areas. Mature timber of nearly pure hemlock growing in sheltered situations is preferred by the looper.

Black-headed budworm damage is most severe on understory trees. Foliage injured by the feeding larvae soon turns brown. Much of this colored foliage remains on the tree, clinging to the webbing of a loosely constructed shelter which the larvae spin among the twig tips. After feeding by the budworm has been completed for the season, the trees often put forth new foliage which partially obscures the damage.

Hemlock sawfly larvae feed on the older foliage. Much of the needle is consumed; the remaining portion fades, causing the stand to appear somewhat yellow or brown. Attacks first occur on the lower branches, making light infestations difficult to detect from the air.

4. Sitka spruce--The spruce aphid attacks Sitka spruce growing in the coastal areas of Oregon and Washington. This insect sucks the juice from the old needles causing them to fade, die, and fall. The yellowish foliage and the brownish cast of the exposed twigs after the needles drop are the principal clues to an outbreak of the spruce aphid. The evidence is most conspicuous early in the season before it is obscured by new foliage.

5. Lodgepole pine--Lodgepole sawfly epidemics are spectacular. Reddish brown areas can be seen for many miles. This coloration is the result of larval feeding on the old needles many of which, partly consumed, remain on the twigs and fade. The evidence is most conspicuous shortly after pupation of the sawfly starts. Later in the season new needle growth tends to hide the damage. Trees of all ages are attacked.

Lodgepole needle miner larvae attack and hollow out the old needles. The empty shells soon turn yellow and may remain on the branches a month or more. Damage is most conspicuous about the time when the needle miner pupates. The infestation first appears on the lower branches and moves upward in the crown as the population intensity increases.

The pine budworm prefers sapling to pole-size stands. It attacks the current season's needle growth. Immature larvae hollow out the bases of the needles. The mature larvae consume the outer portions of the needles and frequently web a number of twig tips together. Needles injured by feeding, fade and become most conspicuous shortly after budworm pupation starts.

6. Ponderosa pine--Pine butterfly larvae start feeding at the tips of ponderosa pine needles and work toward the base. They usually consume the entire needle, and as a result there is little discoloration of foliage. Mature stands are most seriously affected. No outbreaks of the pine butterfly have been observed from the air in Oregon and Washington. In Idaho in 1953 it was found that the number of butterflies fluttering about the tree tops was the best basis for mapping an outbreak. The survey plane must be flown about 500 feet above the timber.

Pandora moth larvae attack ponderosa pine of all ages. In the early stages feeding is more intensive on the lower crowns. Since the larvae consume entire needles there is little discoloration of foliage. The sparseness or absence of foliage provides the principal evidence of an outbreak. No outbreak has yet been observed from the air in Oregon and Washington.

Pine sawfly activity on ponderosa pine in Oregon and Washington has been largely confined to sapling, and pole-size stands. The larvae eat the old needles, starting at the tip and working toward the base, usually consuming the entire needle. The only visible evidence of an outbreak from the air is the sparse foliage.

The pine budworm attacks the new needles of ponderosa pine saplings and poles. Young larvae hollow out the bases of the needles while the older larvae consume the outer portions. Many of the severed and partly consumed needles adhere to webs made by the larvae. The needle fragments soon turn reddish brown and are most evident from the air about the time the budworm pupates.

7. Western larch--The larch bud moth attacks larch of all ages, but has not been recorded as a tree killer in the Pacific Northwest. The larvae usually eat the pulp of a needle leaving much of the outer shell. The hollowed-out needles turn light brown making it easy to detect an outbreak from the air. Evidence of an outbreak is most conspicuous about the time the budworm pupates. After that, the dead needles soon drop. Frequently they are replaced by new foliage.

Bark Beetle Surveys

Bark beetles characteristically attack individual trees and trees in groups, killing them in one year; whereas, defoliators attack extensive stands, often taking several years to kill. Trees killed by bark beetles often do not fade until the following spring; consequently, the regional survey data on mortality caused by bark beetles lags about one year behind the infestation. Special appraisal surveys are necessary for control action.

Climatic conditions affect the detection of bark beetle loss in two ways: (1) Wind and rain remove dead and dying needles from killed trees making recognition of recent mortality difficult; and (2) cloud shadows, smoke, or haze reduce visibility.

Table 2. Aerial reconnaissance schedule for bark beetle outbreaks in Oregon and Washington

Tree Species	Bark Beetle	Survey Period
Douglas-fir	Douglas-fir beetle	
	East of Cascades	June 1 - Sept. 15
	West of Cascades	Sept. 15 - Nov. 15 & May 15 - Aug. 1
	Douglas-fir engraver beetle	May 1 - July 15
Ponderosa pine	Western pine beetle	June 1 - July 15
	Mountain pine beetle	June 15 - Sept. 1
	Oregon pine engraver	May 15 - July 1
True firs	Fir engraver beetle	July 1 - Sept. 1
	Silver fir beetles	July 1 - Sept. 1
Engelmann spruce	Engelmann spruce beetle	March 15 - Aug. 1
Lodgepole pine, western white pine whitebark pine sugar pine	Mountain pine beetle	June 15 - Sept. 1

1. Douglas-fir--The Douglas-fir beetle causes extensive damage to Douglas-fir forests in the Northwest. Surveys of damage must take into account differences in the rate of foliage fade between trees killed in the high dry areas east of the Cascade Range and in the moist region west of the summit.

East of the Cascades trees killed during the current season usually remain green during the winter and start to fade early in the spring. By midsummer the trees are well-colored. The needles start to fall soon after, and little foliage remains by the end of the second winter.

West of the Cascades about half the trees killed early in the current year start to fade in late summer and are well-colored by late fall. These trees lose all foliage during the ensuing winter. The foliage on the remainder of the current year's loss remains green through the winter, starts to fade in the spring, turns dark red by midsummer, and drops off that winter. Therefore, two surveys are necessary to obtain a complete picture of one year's Douglas-fir beetle losses west of the Cascades.

The Douglas-fir engraver beetle normally breeds in slash but under certain conditions will attack living trees of all ages. Some saplings and poles may be killed but the engraver beetle is especially destructive to the tops of young sawlog stands. Mature trees do not suffer extensive damage. Attacks occur throughout the summer. Tops of Douglas-fir trees killed early in the summer are sorrel by fall, whereas those attacked in late summer remain green through the winter and fade early the next spring.

2. Ponderosa pine--The western pine beetle is the most destructive enemy of mature ponderosa pine. It attacks and kills trees singly or in groups of up to several hundred. Usually two broods develop during a year in the Northwest. Foliage of trees killed by this insect during the late spring and through the summer frequently starts to fade within two weeks after attack, and by fall is sorrel in color. Some trees killed during the fall remain green through the winter, but early the next summer the foliage of these trees turns bright red or sorrel. While some of the killed trees lose all their needles within a year, others may retain much of their foliage up to two years. The best time in which to obtain an accurate picture of the past year's loss is in late spring or early summer, when the past year's kills have completely faded and current season's attacks have not yet started to fade.

The mountain pine beetle attacks ponderosa pine of all ages but becomes most aggressive in dense immature stands, generally of pole-size trees. In these stands the insect frequently kills groups of several hundred trees. One brood develops each year. The adults attack during the summer. A few of the killed trees may partially fade by fall, but the majority remain green through the winter and fade the next spring. In the sapling stands of ponderosa pine the mountain pine beetle is frequently associated with the Oregon pine engraver.

The Oregon pine engraver breeds primarily in slash from cuttings, windthrow, or snowbreak. Under favorable conditions the broods develop in tremendous numbers and attack ponderosa pine saplings and poles, frequently killing large groups which may extend over several acres. Under certain conditions the tops of mature trees are also attacked and killed. Although the insect produces many overlapping broods throughout the summer, the attacks on green stands usually occur during July and August. Most of the foliage on killed trees is bright sorrel by fall; but some trees remain green through the winter and fade in early spring.

3. True firs--The fir engraver attacks true firs and at times is exceedingly destructive. The attacks occur during the early part of the summer. A portion of the loss fades before winter; the remainder of the trees fade early the next spring. The needles usually start to fall soon after a tree has faded.

The silver fir beetles have caused much damage to Pacific silver fir stands in western Washington and northwest Oregon in recent years. These insects frequently attack in patches along the tree trunk and sometimes may take several years to kill a tree. The attacks occur in July and August, but foliage does not begin to fade until late spring of the next year. By midsummer most of the dead trees are well faded. The foliage falls rapidly after fading. Little discolored foliage remains on the tree the next spring.

4. Engelmann spruce--The Engelmann spruce beetle is the primary insect enemy of this tree species. Attacks may continue throughout the year, but the majority occur in early summer. Under favorable conditions one brood will develop during the year; at high elevations, however, the brood may require two years to complete its development. Most dead trees lose their needles without conspicuous fading. Under normal conditions needles start to drop during the late fall, and by late spring few needles remain on the tree. The visible evidence of an active outbreak from the air is slight fading of the foliage or a brownish appearance of the twigs on trees without foliage.

5. Lodgepole pine, western white pine, whitebark pine, and sugar pine--The mountain pine beetle is the primary insect enemy of these tree species and often kills large groups. In lodgepole pine, infestations may contain groups of thousands of trees. There is one brood per year. Attacks largely occur during midsummer. A few attacked trees fade by fall but the majority remain green through the winter. By midsummer all beetle-killed trees are a bright sorrel color.

Conditions Resembling Forest Insect Damage

From the air many other conditions or types of damage resemble insect-caused damage. Some conditions resemble defoliation (table 3)--others, bark beetle damage (table 4)

Table 3. Conditions resembling defoliation

Tree Species	Condition
Douglas-fir	Needle disease, winter injury, frost injury, heavy cone crop, hail damage
True firs	Winter injury, frost injury, needle disease
Western hemlock	Flooding
Larch	Needle disease
Lodgepole pine	Needle disease, flooding
Ponderosa pine	Needle disease, winter injury, hail damage
Engelmann spruce	Heavy cone crop

Table 4. Conditions resembling bark beetle damage

Tree Species	Condition
Douglas-fir	Bear damage, root rot, spot fires, water kill, mistletoe
True firs	Spot fires, porcupine damage, water kill, mistletoe
Western hemlock	Root rot, water kill
Lodgepole pine	Needle disease, water kill
Ponderosa pine	Needle disease, mistletoe, porcupine damage, spot fires, water kill
Sugar pine	Blister rust
Western white pine	Blister rust, water kill

Survey Techniques

The airport selected for the center of operations should have: (1) Good runways with a surface that can be used in all weather; (2) radio or CAA facilities for obtaining current weather information in work areas and weather forecasts (figure 1), and for filing flight plans (figure 2); (3) good maintenance facilities and proper fuel as required; and (4) adequate hanger or tie-down facilities. A flight plan is filed with a CAA or U. S. Forest Service office and position reports are transmitted by radio at least every half hour during survey flights.

Division of Survey Area

The forested areas of Oregon and Washington are divided into natural operational blocks for the regional aerial survey. A natural operational block includes three or more national forests. Whenever possible the operating base is located near the center of an operational block; this location, together with careful flight planning, reduces ferry time to a minimum. The program is kept exceedingly flexible to enable shifting of survey flights from one portion of the region to another should weather conditions become unfavorable.

Flight Pattern

An inspection of aeronautical charts and U. S. Forest Service maps will for the most part determine the method by which an area is to be flown. Two basic flight patterns are commonly used in the Northwest for aerial reconnaissance. The "gridiron" pattern provides coverage of an area by flight lines flown in cardinal directions at specified distances between lines; this method applies to level plateaus, gently rolling terrain, and terrain that is extremely chopped up by short drainages. The "contour" pattern, as the name implies, follows the contours of the land in flights at various elevations. Deeply dissected, rough, high-elevation terrain, or individual mountains with definite drainage patterns lend themselves most naturally to this type of coverage. Since most operational blocks contain many kinds of terrain, a combination of patterns is usually used.

Flight Line Spacing

Flight lines are spaced according to the maximum width for effective observation on each side of the plane and the desired percent of aerial coverage for the area to be surveyed. The "effective observational strip width" is the maximum distance from which an experienced aerial observer can discern forest insect infestations under the prevailing conditions.

Fig. 1. Survey crew being briefed by weather analyst.

Fig. 2. Pilot filing flight plan with CAA as safety measure.

Experience from mapping bark beetle damage on the regionwide aerial survery during the past 7 years has shown that under optimum conditions the maximum effective width of strip over level to gently rolling terrain for a single observer is 2 miles on each side of the plane. Flight lines are spaced 4 miles apart. When 2 observers view terrain on opposite sides of the plane the maximum distance for each is 3 miles. Thus, flight lines under ideal conditions are spaced 6 miles apart. Maximum effective width of strip is reduced 1/2 mile to map defoliator damage.

When flying a gridiron pattern over chopped up terrain, the width of strip is reduced sufficiently to permit observers to look into stream bottoms. Survey flights in deep canyons generally follow the contour midway between the ridge top and the canyon bottom. One observer can cover a narrow canyon in a single flight. Canyons 2 or more miles wide may require two flights for a single observer (up one side and back the other) so that all short side drainages may be properly inspected. When two observers are aboard and canyon width exceeds 3 miles, two flights in the drainage may be necessary.

The primary factors that determine the effective observational strip width are atmospheric conditions (haze, clouds, and smoke) and type of forest insect infestations. Recommended observational strip widths for various atmospheric conditions are as follows:

Atmospheric Conditions	Width of Strip
1. Clear, bright, cloudless	3 miles
2. Less than 3/10s clouds, widely scattered cumulus clouds	3 miles
3. Light haze	2-1/2 miles
4. High thin cirrus overcast	2 miles
5. Moderate haze	1-1/2 - 2 miles
6. 3/10s to 5/10s clouds, or light smoke	1-1/2 miles
7. More than 5/10s clouds	Survey impractical
8. Heavy haze or moderate smoke	Survey impractical

Light epidemic defoliation and small groups of beetle-killed trees will probably be overlooked when effective lateral visibility is reduced to less than 2 miles. Forest areas in cloud shadows are extremely difficult to inspect because of the sharp contrast to sunlit areas. Poor accuracy in detecting infestations will result when cloud cover exceeds three-tenths.

Height of Flight

Height of flight usually ranges from 800 feet to 1,500 feet above terrain. A maximum altitude of 2000 feet above terrain is used only on clear, bright cloudless days. Under less favorable conditions the height of flight is progressively reduced, but not to less than 500 feet above terrain.

The regionwide survey generally includes the reconnaissance of both bark beetle and defoliator damage simultaneously (figure 3). Defoliator damage is usually less conspicuous than evidence of killing by bark beetles and therefore determines the altitude at which surveys are flown. Light defoliation, especially where lack of foliage is the only indication of an infestation, is difficult to detect and necessitates flying at minimum height above ground.

Speed of Flight

It has been found that slow cruise airspeeds of 65 to 90 miles per hour are best for making reconnaissance surveys of forest insect conditions. More of the small and light areas of infestation will be spotted, and the boundaries of all infestations will be more accurately located at these speeds. Sketchmapping insect damage at airspeeds in excess of 100 miles per hour is impractical for any except the most generalized type of survey.

Optimum Flying Periods

The period of the year best suited to aerial reconnaissance in Oregon and Washington extends from May 1 to August 15. During these months the sun is at its highest, which provides the maximum hours of daylight and the minimum adverse effect from shadows. Hours during the day when flights should start and stop for each month of the year at the various latitudes in this region are shown in table 5.

Table 5. Optimum time of day to conduct aerial surveys

Time of Year	40° Latitude		45° Latitude		50° Latitude	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Jan. - Feb.	10:00 -	2:00	10:30 -	1:30	11:00 -	1:00
March	9:30 -	2:30	10:00 -	2:00	10:30 -	1:30
April	9:00 -	3:00	9:30 -	2:30	10:00 -	2:00
May - Aug. 15	8:30 -	3:30	9:00 -	3:00	9:30 -	2:30
Aug. 16 - Sept. 15	9:00 -	3:00	9:30 -	2:30	10:00 -	2:00
Sept. 16 - Oct. 15	9:30 -	2:30	10:00 -	2:00	10:30 -	1:30
Oct. 16 - Dec. 31	10:00 -	2:00	10:30 -	1:30	11:00 -	1:00

On predominantly east slopes the schedule may be advanced an hour, and on west exposures retarded an hour, in order to take advantage of all favorable lighting conditions. In some localities, however, it may be necessary to delay the starting time until deep canyons and steep north or west slopes become illuminated.

On certain favorable days the survey period may exceed 7 hours. However, the actual daily time in flight does not usually exceed 6 hours. Flying time is broken into two periods with a 1-hour rest period between flights to relieve pilots and observers from eye strain and muscular fatigue after flying or observing continuously for 2-1/2 hours to 3-1/2 hours.

Preflight Procedures

The survey crew has several responsibilities for operational planning before take-off each morning. The pilot has the general responsibility for the airplane and its contents. This includes a general inspection of the airframe and engine, a check on gas and oil needed for the survey flight, a thorough cleaning of all windows, a check on safety equipment for plane and personnel, and the preparation of a flight plan to be filed with the CAA. (If a CAA facility is not available the flight plan is filed with some Federal, State, or private agency in the locality for appropriate action in case of emergency.)

The observer secures all necessary maps smoothly to map boards for efficient handling and storing in the plane. He also has at least two sets of sharpened colored pencils and an eraser. If the observer is subject to airsickness, dramamine should be taken at least one half hour before flight.

The survey crew schedules the area and the approximate coverage for the morning and afternoon flights, decides on the airport for refueling and the noon stop, and schedules specific intervals (usually 30 minutes) for reporting the plane's position to the CAA or other radio facility.

Observing and Sketchmapping

Techniques for observing and sketchmapping insect infestations developed on these surveys during the past seven years have now become standard procedure.

The chief observer occupies the right front seat in the plane. He directs the pilot as to course to fly and determines the width of observational strip except when flight lines are predrawn on the map. At all times he determines the height to fly, closely follows the plane's course, and accurately draws the line of flight on the map with a purple pencil as the flight progresses. He detects all types of insect damage, determines the tree species, and evaluates the damage. By knowing the exact position of the plane he sketches in place on the map the type and intensity of the damage. Infestation boundaries that are clear cut can be drawn on the 1/4-inch per mile map with an accuracy of 1/4 mile or better. Spot infestations are difficult to sketch on this scale map because a pencilled dot small enough to denote the actual size of a small infestation may be overlooked in later acreage computations. Therefore, small spot infestations are mapped at a visible size with appropriate footnotes. Greater accuracy is achieved by using larger scale maps. When alone, the observer views the forested area on both sides of the plane. When there are two, the chief observer confines his attention to insect conditions forward and on the right side of the plane. The second observer, who occupies the left rear seat, detects and maps all infestations visible from the left side of the plane (figure 4). If he lacks sufficient mapping experience he alerts the chief observer to map the infestation detected. Data mapped by the second observer is transferred to the chief observer's map upon completion of the day's flying.

When infestations are detected the airplane is flown at slower speeds (65 m.p.h.) to provide sufficient time to map the outbreak accurately. Small, well-defined centers of damage can usually be mapped without altering the course of the plane. Indefinite or larger infestations are circled and if necessary flown at lower altitude until boundaries, intensity, and identity of the insect infestation have been recorded. When extensive outbreaks are encountered they are mapped only to the edge of the immediate observational strip. Mapping is completed on adjacent strips.

Fig. 3. Survey plane on sketchmapping mission.

Fig. 4. Aerial survey crew in action. (Door removed to show details of equipment).

An experienced aerial survey crew does not require the use of pre-inscribed flight lines on the maps but can judge spacing and distribution of flight lines according to the time available and by the timber type, terrain, and observing conditions.

Mapping Standards

Standards for sketchmapping forest insect infestations from the air have been developed for both defoliators and bark beetles through extensive experience on the ground and from aerial observations.

Defoliator Damage--Five degrees of epidemic defoliation by budworm, tussock moth, or other defoliators are classified from the air, as follows:

Light - Defoliation light, barely visible from the air
Moderate - Top 1/4 of tree defoliated
Heavy - 1/2 of tree defoliated, top killing in progress
Very Heavy - 3/4 of tree defoliated, severe, some tree killing in progress
Dead - Defoliation complete, general tree killing

Boundaries for each of these five degrees of defoliation are drawn on the map with colored pencil using the following color scheme: Blue indicates light defoliation; green, moderate; orange, heavy; red, very heavy; and brown, complete defoliation or dead stands.

Letters are inscribed on the aerial map according to the Forest Insect Aerial Survey Mapping Legend (appendix page 40) within or adjacent to the infestation boundary to identify the defoliator and the timber type.

Bark Beetle Damage--Criteria used in mapping intensity of bark beetle damage on the regionwide aerial survey are: (1) Number and distribution of dead trees per section, and (2) number of dead trees per group. A classification of intensity and grouping of damage per section is used for various tree species (table 6). These criteria are tempered by such factors as age and size of stand, and density of stocking.

The same color scheme used in mapping defoliator damage is employed to show various degrees of bark beetle damage. Infestation intensity boundaries are outlined on the aerial map with the proper color. The number or number-letter combination placed adjacent to or within the infestation boundary to identify the bark beetle responsible for the damage follows the Forest Insect Aerial Survey Mapping Legend (appendix page 40).

The 1954 survey flight map of the Mt. Hood National Forest and adjacent timber lands (appendix page 41) shows actual forest insect infestations mapped.

Table 6. Intensity classification of bark beetle infestations for aerial reconnaissance surveys in Oregon and Washington

Timber Types[1/]	Light	Moderate	Heavy	Very Heavy
Ponderosa pine, Sugar pine	20-50 trees per section, 5 trees or less per group.	50-100 trees per section, 10 trees or less per group.	100-200 trees per section, 20 trees or less per group.	200 or more trees per section, large groups.
Lodgepole pine, Whitebark pine	50-350 trees per section, 50 trees or less per group.	350-1000 trees per section, 200 trees or less per group.	1000-2600 trees per section, 400 trees or less per group.	2600 or more trees per section, large groups.
Douglas-fir	20-50 trees per section, 5 trees or less per group.	50-150 trees per section, 15 trees or less per group.	150-300 trees per section, 30 trees or less per group.	300 or more trees per section, large groups.
True firs, Engelmann spruce, White pine	20-50 trees per section, 5 trees or less per group.	50-150 trees per section, 15 trees or less per group.	150-300 trees per section, 30 trees or less per group.	300 or more trees per section, large groups.

1/ Timber types are based on predominant species according to Forest Type Classification for the Pacific Northwest Region (U.S. Forest Service).

Ground Checking Survey Data

The season in which damage caused by forest insects is most conspicuous from the air varies with each species of insect. The damage caused by some insects may not be especially evident at the time of aerial survey; and, therefore, the observer may underrate the severity of the infestation. Other times the observer may not be able to tell which of several insects caused the damage. Also there are many other phenomena which from the air closely resemble damage caused by insects (tables 4 and 5). For these reasons it is difficult to correctly identify all types of damage from the air.

All major centers of damage mapped from the air are ground checked in part by the aerial observers during periods of poor flying weather and in part by special ground crews. Ground checks verify the identity of the insect or cause of damage, evaluate the degree of damage, and determine more accurately the boundaries of infestations. Ground checking by aerial observers of areas they have mapped improves their identification of insect damage and their sketchmapping accuracy.

Map Preparation and Acreage Determination

All data from flight maps and ground checking information are entered on final master maps for each state. Centers of damage are located, the insect responsible is designated by number or letter, colors denote the degree of infestation, and flight lines are drawn to show the intensity of coverage. A Forest Insect Aerial Survey Mapping Legend is attached to each completed map.

Acreages of infestations are determined for each insect and damage intensity from the master map by use of a dot-grid or planimeter. By means of overlay sheets showing ownerships the acreage of infestations on private, State, and Federal land is also determined. Summary B in the Appendix, Forest Insect Infestations Recorded on Aerial Reconnaissance Surveys in Oregon and Washington, shows the total acreage of insect infestation mapped from the air since 1931.

PART III

SURVEY COSTS

Aircraft Operating and Rental Costs

Aerial reconnaissance surveys in Oregon and Washington have been made chiefly in airplanes owned and operated by the Federal Government and co-operators (see Summary A, Appendix). Rented airplanes have been used to some extent. There are three principal advantages for an organization to own and operate its own plane for forest insect surveys: First, the plane can be maintained in top condition, assuring maximum safety; second, the plane is always available when survey conditions are favorable; and third, the cost is less. Generally there are hardly enough good days during the year to complete the necessary surveys. It is often impossible to rent the proper type of aircraft on short notice when optimum weather develops, or to know what condition the plane is in, or to be able to fly minimum contracted hours during certain periods of the year.

To illustrate the increased operational costs of large aircraft over small aircraft, we can compare the hourly costs of a 5-place Cessna 195 (300 hp) with a 4-place Cessna 170 (145 hp) for a 300-hour period. At 1953-54 prices in the Northwest, the larger plane costs twice as much per hour to operate (table 7).

Table 7. Hourly operating costs for two airplanes

Item	Cessna 195	Cessna 170
Gasoline and oil	$5.50	$2.80
Radio maintenance	.15	.15
Engine maintenance, checks, etc.	3.45	1.35
Hangering and tie down	.70 ($20.00 month)	.50 ($15.00 month)
Parachute maintenance	.20	.20
Total	$10.00	$5.00

A contingency fund for normal airplane depreciation is not maintained by federal agencies; but the depreciation rates for these two planes new in 1954 (fully depreciated in 5 years, 300 flying hours per year) are $13 and $6 per hour respectively. Total costs of operation and depreciation are much less than rental fees.

Hourly rental charges vary with the type of survey aircraft, the total flying hours, and the total number of days required to complete the survey. Airplane contracts may include maintenance, operating costs, insurance and pilot's services. Average aircraft rentals for a 50-hour minimum in the Northwest (including all costs except that of survey pilot) range from $8 per hour for 2-place planes and $14 for 4-place planes to $30 for 5-place planes.

Bid specifications for renting a survey plane are shown in the Appendix, page 35. More information in regard to planes, pilots, and equipment is given in the U. S. Forest Service Air Operations Handbook.

Regionwide Survey Costs

An estimate of the costs for an aerial survey include (1) the hourly rental and operational costs of the selected plane, (2) the total number of flying hours for the survey, based on total area and the intensity of coverage (spacing of flight lines), (3) the salaries of aerial and ground personnel, and (4) the expense of maintaining all personnel during the survey (per diem, transportation, maps, equipment, etc.).

The regionwide reconnaissance of the 49,000,000 timbered acres in Oregon and Washington is flown in approximately 220 hours. On the average, 195 hours are spent sketchmapping and 25 hours in ferry time. Approximately 270,000 acres are surveyed per hour with flight lines spaced 6 miles apart (3 mile observational strips). The total cost is more than $11,000 when an airplane is rented (table 8). This amounts to 23 cents per thousand acres. When federal- or state-owned planes are used, the total costs are reduced by $1,980. (19 cents per thousand acres)

Table 8. Example of costs for regionwide survey in Oregon and Washington

Item	Cost
Plane Rental	
Cessna 170B, 220 hours at $14.00 per hour	$3,080.00
Aerial Personnel (2-1/2 months)	
Salaries	
Pilot	1,050.00
2 Observers	2,110.00
Field Expenses	
Per diem 150 man-days at $9.00	1,350.00
Miscellaneous	50.00
Ground Personnel (3 months)	
Salaries	
2 Field Checkers	2,100.00
Field Expenses	
Per diem 120 man-days at $6.00	720.00
Transportation, 5,000 miles at 7¢	350.00
Miscellaneous	50.00
Office Personnel (1-1/2 months)	
Salary	
1 Draftsman	530.00
Maps, etc.	40.00
Total	$11,430.00

PART IV

A P P E N D I X

SUMMARY A. FOREST INSECT AERIAL RECONNAISSANCE SURVEYS IN OREGON AND WASHINGTON

Year	Location	Forested Acres Surveyed	Survey Agency	Survey Aircraft	Flying Hours
1931	Pacific County, Wash.	230,000	B.E.P.Q. & W.S.D.F.	Hisso Standard	4.0
1932	Pacific & Grays Harbor Counties, Wash.	460,000	B.E.P.Q. & W.S.D.F.	Hisso Standard	7.0
1944	Northwestern Oregon	320,000	B.E.P.Q.	BT-13 and DC-3	3.5
	Northwestern Wash.	1,240,000	B.E.P.Q.	Grumman Widgeon	3.0
	Total	1,560,000		Total	6.5
1945	Northwestern Oregon	320,000	B.E.P.Q. & C.Z. Co.	Fairchild	3.0
	Southwestern Wash.	230,000	B.E.P.Q. & C.Z. Co.	Fairchild	8.0
	Total	550,000		Total	11.0
1947	Northeastern Oregon	150,000	B.E.P.Q., U.S.F.S. & Central Aircraft	Stinson Voyager	7.8
				Ercoupe	5.5
	Blue Mountains, Oregon	7,755,000	B.E.P.Q.	N3N	17.6
			B.E.P.Q. & U.S.F.S.	Stinson Voyager	16.5
	Total	7,905,000		Total	47.4
1948	Blue Mts. & Eastern Oregon Cascades	6,898,900	B.E.P.Q.	N3N	43.0
			B.E.P.Q.	Stinson Reliant	5.0
	Western Oregon Cascades	3,750,000	B.E.P.Q. & U.S.F.S.	Stinson Voyager	4.0
		715,000	B.E.P.Q. & O.S.B.F.	Stinson Voyager	17.0
	Total	11,363,900		Total	69.0

SUMMARY A. Continued

Year	Location	Forested Acres Surveyed	Survey Agency	Survey Aircraft	Flying Hours
1949	Western Oregon	15,670,400	B.E.P.Q. & O.S.B.F.	Cessna 170	59.3
			B.E.P.Q. & O.S.B.F.	Stinson Sta. Wagon	5.9
	Blue Mts. & Eastern			Luscombe T8F	65.0
	Oregon Cascades	13,554,400	B.E.P.Q.	Cessna 140	4.0
	Eastern and Western			Cessna 170	41.7
	Washington	13,554,500	B.E.P.Q.	Luscombe T8F	15.8
				Cessna 195	23.7
	Total	42,779,300		Total	215.4
1950	Western Oregon	15,670,400	O.S.B.F.	Stinson Sta. Wagon)	114.7
	Eastern Oregon Cascades	6,590,500	O.S.B.F.	Stinson Sta. Wagon)	
	Blue Mountains Oregon	6,964,000	B.E.P.Q.	Cessna 195	22.7
	Eastern & Western Wash.	19,775,100	B.E.P.Q.	Cessna 195	65.8
	Total	49,000,000		Total	203.2
1951	Western Oregon	15,670,400	O.S.B.F.	Cessna 170	87.6
	Eastern Oregon Cascades	6,590,500	B.E.P.Q.	Cessna 195	22.0
	Blue Mountains Oregon	6,964,000	B.E.P.Q.	Cessna 195	26.1
	Eastern Washington	8,001,100	B.E.P.Q.	Cessna 170 & 195	21.8
	Western Washington	3,710,300	B.E.P.Q.	Cessna 170	31.8
	Western Wash. Cascades	8,063,700	B.E.P.Q.	Cessna 170 & 195	31.5
	Total	49,000,000		Total	220.8
1952	Western Oregon	7,142,400	B.E.P.Q. & O.S.B.F.	Cessna 170	45.6
	Eastern Oregon Cascades	6,590,500	B.E.P.Q. & O.S.B.F.	Cessna 170	28.4
	Blue Mountains Oregon	6,964,000	B.E.P.Q. & O.S.B.F.	Cessna 170	36.6
	Eastern Washington	8,001,100	B.E.P.Q.	Cessna 170	38.7
	Western Washington	6,360,000	B.E.P.Q.	Cessna 170	26.6
	Total	35,058,000		Total	175.9

SUMMARY A. Continued

Year	Location	Forested Acres Surveyed	Survey Agency	Survey Aircraft	Flying Hours
1953	Western Oregon	14,010,400	B.E.P.Q. & O.S.B.F.	Cessna 170	53.1
	Eastern Oregon Cascades	6,590,500	B.E.P.Q. & O.S.B.F.	Cessna 170	29.1
	Blue Mountains Oregon	6,964,000	B.E.P.Q. & O.S.B.F.	Cessna 170	35.9
	Eastern Wash. Cascades	8,001,100	B.E.P.Q. & W.S.D.F.	Cessna 180	30.0
	Western Washington	11,774,000	B.E.P.Q. & W.S.D.F.	Cessna 180	45.2
			B.E.P.Q. & W.T.Co.	Cessna 170B	11.0
	Total	47,340,000		Total	204.3
1954	Western Oregon	15,670,000	O.S.B.F. & U.S.F.S.	Cessna 170	68.6
	Eastern Oregon Cascades	6,590,000	U.S.F.S.	Cessna 170	33.0
	Blue Mountains Oregon	6,964,000	O.S.B.F. & U.S.F.S.	Cessna 170	40.3
	Eastern Wash. Cascades	7,148,000	A.R.S. & U.S.F.S.	Cessna 180	26.7
	Western Washington	11,774,000	A.R.S. & U.S.F.S.	Cessna 170 & 180	45.7
	Total	48,146,000		Total	214.3

A.R.S. - Agriculture Research Services
B.E.P.Q. - Bureau of Entomology and Plant Quarantine
C.Z.Co. - Crown Zellerbach Co.
O.S.B.F. - Oregon State Board of Forestry
U.S.F.S. - U.S.Forest Service
W.S.D.F. - Washington State Division of Forestry
W.T.Co. - Weyerhaeuser Timber Co.

SUMMARY B. FOREST INSECT INFESTATIONS RECORDED ON AERIAL RECONNAISSANCE SURVEYS IN OREGON AND WASHINGTON

(Infestations by Thousand Acres)

Insects	1931	1932	1944	1945	1947	1948	1949	1950	1951	1952	1953	1954
DEFOLIATORS												
Hemlock looper	32	52	21	76	-	-	-	5	5	12	-	-
Black-headed budworm	-	-	168	-	-	-	-	-	-	-	-	-
Douglas-fir tussock moth	-	-	-	-	127	15	-	-	-	-	-	-
Spruce budworm	-	-	-	-	710	1,446	2,232	2,036	1,651	1,579	1,136	1,034
Larch bud moth	-	-	-	-	-	-	130	12	23	2	4	-
Lodgepole sawfly	-	-	-	-	-	-	8	-	-	22	70	-
Fir sawfly	-	-	-	-	-	-	-	4	-	-	1	-
Lodgepole needle miner	-	-	-	-	-	-	-	-	-	9	-	-
Spruce aphid	-	-	-	-	-	-	-	-	-	-	23	4
Pine budworm	-	-	-	-	-	-	-	-	-	-	2	-
Balsam woolly aphid	-	-	-	-	-	-	-	-	-	-	-	203
Sub Total	32	52	189	76	837	1,461	2,370	2,057	1,679	1,624	1,236	1,241
BARK BEETLES												
Douglas-fir beetle	-	-	-	-	-	-	1	58	3,120	4,570	4,833	5,072
Western pine beetle	-	-	-	-	-	-	6	19	303	674	1,001	258
Mountain pine beetle	-	-	-	-	-	-	106	271	260	271	322	207
Silver fir beetles	-	-	-	-	-	-	43	59	243	162	603	709
Oregon pine engraver	-	-	-	-	-	-	2	84	41	92	76	40
Fir engraver	-	-	-	-	-	-	-	-	3	13	118	56
Engelmann spruce beetle	-	-	-	-	-	-	-	-	-	1	7	12
Sub Total	-	-	-	-	-	-	158	491	3,970	5,783	6,960	6,354
Grand Total	32	52	189	76	837	1,461	2,528	2,548	5,649	7,407	8,196	7,595

BID SPECIFICATIONS FOR RENTAL OF AIRPLANE TO BE USED ON FOREST INSECT SURVEYS

Rental of airplane for the period Aug. 27 to Sept. 30, 1954 inclusive, as specified below -

General:

(1) For the purpose of aerial reconnaissance and observation of forest areas in Oregon and Washington for the detection of insect damage.

(2) The aircraft to be furnished must have the following requirements:
- (a) High wing monoplane, equal or better than Cessna model 170.
- (b) 4 place
- (c) Minimum 145 horsepower engine
- (d) Excellent lateral and forward visibility
- (e) All metal construction
- (f) Radio equipment:
  - (1) Transmitter min. 50 mile range
  - (2) Receiver min. 100 mile range
- (g) Age: Plane must have been mfg. since Jan. 1, 1952 with less than 1,000 air frame hours and less than 400 hours on the engine since major overhaul.
- (h) Must be certificated and airworthy.

Bidder to furnish the following information regarding equipment offered:

MAKE OF EQUIPMENT ______________________________

YEAR AND MODEL ______________________________

NC NUMBER ______________________________

ENGINE H.P. ______________________________

NUMBER HOURS FLYING TIME SINCE MAJOR OVERHAUL OF ENGINE ______________

AIR FRAME ______________________________

RANGE: MILES __________ HOURS __________ FUEL CAPACITY __________

(3) VALUATION DATA

DATE AIRCRAFT ACQUIRED BY PRESENT OWNER (month and year) __________

COST TO PRESENT OWNER $____________________

PRESENT BOOK VALUE $____________________

COST August 27, 1954 TO REPLACE THIS AIRCRAFT $____________________

(4) The Government will furnish the pilot, hanger space, gasoline, oil and other supplies needed for proper maintenance of the equipment during the rental period. Periodic checks, if required to maintain CAA certificates will be performed at contractors expense.

(5) The cost of minor repairs for maintenance will be paid for by the Government, however, major repairs due to structural or mechanical failures will be paid by the bidder, except for negligence on the part of the Government or its employees.

(6) Any claim for damage to, or loss or destruction of the equipment covered by this contract occurring during the period of rental, will be considered under applicable laws and regulations, in accordance with the appraised replacement value as shown under Cond. #3 of this bid.

(7) The equipment will be picked up and returned to the bidder's place of business in the same condition as received, except for normal depreciation and wear.

(8) Any equipment offered must be supplied in good operating condition, subject to inspection by a qualified Government employee, whose judgement as to operating conditions shall be final under this contract. Any equipment offered, which does not meet inspection standards will be rejected.

(9) <u>Bidder will quote below on the following basis:</u>

RATE PER HOUR $__________

It is planned to operate plane under this contract for approximately 50 hours if weather conditions permit. Plane will not be held for a period longer than two calendar months.

Payment will be made for actual hours used as determined by Government pilot.

Payment will be made upon termination of the rental period provided invoice in proper form has been furnished.

Execution of contract is conditioned upon the passage of appropriations by Congress from which expenditures thereunder may be made and shall not obligate the Forest Service upon failure of Congress to so appropriate.

Form AD 32 General Provisions (Supply Contract) forms a part of this invitation.

AERIAL SURVEY PERSONNEL 1947-1954

Year	Name	Agency
1947	W. J. Buckhorn	B.E.P.Q.
	J. F. Wear	B.E.P.Q.
	L. Sohler	U.S.F.S.
1948	W. J. Buckhorn	B.E.P.Q.
	J. F. Wear	B.E.P.Q.
	R. Berry	O.S.B.F.
	J. Brigham	O.S.B.F.
	A. Lindsten	O.S.B.F.
	L. Sohler	U.S.F.S.
1949	W. J. Buckhorn	B.E.P.Q.
	R. Heller	B.E.P.Q.
	J. F. Wear	B.E.P.Q.
	K. H. Wright	B.E.P.Q.
	J. Brigham	O.S.B.F.
	A. Lindsten	O.S.B.F.
1950	W. J. Buckhorn	B.E.P.Q.
	W. K. Coulter	B.E.P.Q.
	A. T. Davison	B.E.P.Q.
	J. F. Wear	B.E.P.Q.
	K. H. Wright	B.E.P.Q.
	A. Gruba	O.S.B.F.
	A. Larsen	O.S.B.F.
	A. Lindsten	O.S.B.F.
1951	W. J. Buckhorn	B.E.P.Q.
	W. K. Coulter	B.E.P.Q.
	H. L. Haglund	B.E.P.Q.
	J. F. Wear	B.E.P.Q.
	A. Larsen	O.S.B.F.
	W. Slater	O.S.B.F.
	R. Stevens	O.S.B.F.
1952	W. J. Buckhorn	B.E.P.Q.
	W. K. Coulter	B.E.P.Q.
	J. F. Wear	B.E.P.Q.
	K. H. Wright	B.E.P.Q.
	A. Larsen	O.S.B.F.
	A. Lindsten	O.S.B.F.
	R. Stevens	O.S.B.F.
	P. Lauterbach	W.T.Co.

Year	Name	Agency
1953	W. J. Buckhorn	B.E.P.Q.
	R. M. Lamoureaux	B.E.P.Q.
	J. F. Wear	B.E.P.Q.
	A. Larsen	O.S.B.F.
	M. Ramsdell	O.S.B.F.
	F. Murphy	W.S.D.F.
	J. Bartel	W.T.Co.
	P. Lauterbach	W.T.Co.
1954	W. J. Buckhorn	U.S.F.S.
	J. Harrell	U.S.F.S.
	P. W. Orr	U.S.F.S.
	J. F. Wear	U.S.F.S.
	N. Meyer	A.R.S.
	A. Larsen	O.S.B.F.

COMMON AND SCIENTIFIC NAMES OF MORE IMPORTANT TREES AND INSECTS OBSERVED ON AERIAL RECONNAISSANCE SURVEYS IN OREGON AND WASHINGTON

COMMON NAME	SCIENTIFIC NAME
TREES	
Douglas-fir	Pseudotsuga menziesii (Mirb.) Franco
Pacific silver fir	Abies amabilis (Dougl.) Forbes
Shasta red fir	Abies magnifica var. shastensis Lemm.
Subalpine fir	Abies lasiocarpa (Hook.) Nutt.
White fir	Abies concolor (Gord. & Glend.) Lindl.
Mountain hemlock	Tsuga mertensiana (Bong.) Carr.
Western hemlock	Tsuga heterophylla (Raf.) Sarg.
Western larch	Larix occidentalis Nutt.
Lodgepole pine	Pinus contorta Dougl.
Ponderosa pine	Pinus ponderosa Laws.
Sugar pine	Pinus lambertiana Dougl.
Whitebark pine	Pinus albicaulis Engelm.
Western white pine	Pinus monticola Dougl.
Engelmann spruce	Picea engelmannii Parry
Sitka spruce	Picea sitchensis (Bong.) Carr.
BARK BEETLES	
Douglas-fir beetle	Dendroctonus pseudotsugae Hopk.
Douglas-fir engraver	Scolytus unispinosus Lec.
Engelmann spruce beetle	Dendroctonus engelmanni Hopk
Fir Engraver	Scolytus ventralis Lec.
Mountain pine beetle	Dendroctonus monticolae Hopk.
Oregon pine engraver	Ips oregoni (Eichh.)
Silver fir beetles	Pseudohylesinus grandis Sw. and granulatus (Lec.)
Western pine beetle	Dendroctonus brevicomis Lec.
DEFOLIATORS	
Balsam woolly aphid	Chermes piceae (Ratz.)
Black-headed budworm	Acleris variana (Fern.)
Douglas-fir tussock moth	Hemerocampa pseudotsugata Mc.D.
Fir sawfly	Neodiprion spp.
Hemlock looper	Lambdina fiscellaria lugubrosa Hulst
Hemlock sawfly	Neodiprion tsugae Midd.
Larch bud moth	Zeiraphera griseana (Hubner)
Lodgepole needle miner	Recurvaria milleri Busck.
Lodgepole sawfly	Neodiprion burkei Midd.
Pandora moth	Coloradia pandora Blake
Pine budworm	Choristoneura retiniana (Wlsn.)
Pine butterfly	Neophasia menapia Feld.
Pine sawfly	Neodiprion spp.
Spruce aphid	Neomyzaphis abietina (Wlkr.)
Spruce budworm	Choristoneura fumiferana (Clem.)

FOREST INSECT AERIAL SURVEY

MAPPING LEGEND

BARK BEETLES		HOST
1.	Douglas-fir beetle	Douglas-fir
2.	Douglas-fir engraver	Douglas-fir
3.	Engelmann spruce beetle	Engelmann spruce
4.	Fir engraver	True firs
5.	Hemlock engraver	Western hemlock
6L	Mountain pine beetle	Lodgepole pine
6P	Mountain pine beetle	Ponderosa pine
6S	Mountain pine beetle	Sugar pine
6W	Mountain pine beetle	Western white pine
7.	Oregon pine engraver	Ponderosa pine
8.	Western pine beetle	Ponderosa pine
9.	Silver fir beetles	Pacific silver fir

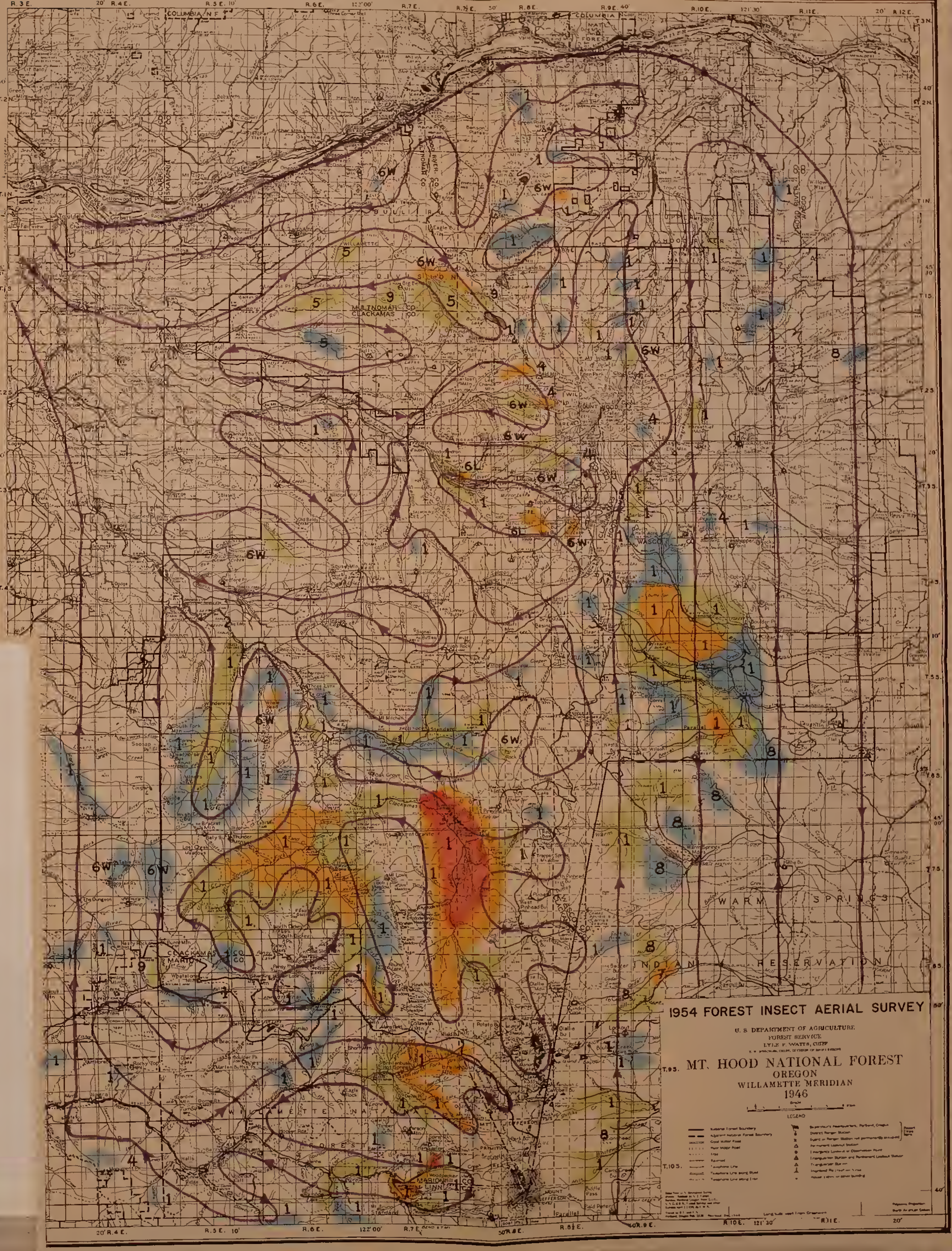
DEFOLIATORS		
A.B.	Aphid, balsam woolly	Pacific silver fir
A.S.	Aphid, spruce	Sitka spruce
B.B.	Budworm, black-headed	True firs - Hemlock
B.L.	Budworm, larch	Western larch
B.P.	Budworm, pine	Ponderosa and lodgepole pine
B.S.	Budworm, spruce	Douglas-fir, True firs, spruce
H.L.	Hemlock looper	Western hemlock
N.M.	Needle miner, lodgepole	Lodgepole pine
P.M.	Pandora moth	Ponderosa pine
P.B.	Pine butterfly	Ponderosa pine
S.F.	Sawfly, fir	True firs
S.H.	Sawfly, hemlock	Western hemlock
S.L.	Sawfly, lodgepole	Lodgepole pine
S.P.	Sawfly, ponderosa pine	Ponderosa pine
T.M.	Tussock moth, Douglas-fir	Douglas-fir, True firs

MISCELLANEOUS	
Blow - Blowdown	All species
Water - Water damage	All species
Flight lines	(Purple color)

COLOR DESIGNATION USED TO INDICATE DEGREE OF DAMAGE

Blue - light
Green - moderate
Orange - heavy
Red - very heavy
Brown - dead


40′
T.2
VANCOUVER 13 MI.
T.1
PORTLAND 11 MI.
45°
30′
T.1
PORTLAND 10 MI.
T.2
20′
T.3
T.4


1954 FOREST INSECT AERIAL SURVEY
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
LYLE F. WATTS, CHIEF
MT. HOOD NATIONAL FOREST
OREGON
WILLAMETTE MERIDIAN
1946
LEGEND
WARM SPRINGS
INDIAN RESERVATION
MULTNOMAH CO.
CLACKAMAS CO.
CLACKAMAS CO.
MARION CO.
WASCO
R.3E.
R.4E.
R.5E.
R.6E.
R.7E.
R.8E.
R.9E.
R.10E.
R.11E.
R.12E.
T.2N.
T.1N.
T.1S.
T.2S.
T.3S.
T.4S.
T.5S.
T.6S.
T.7S.
T.8S.
T.9S.
T.10S.